A probable case of twins in the Short-beaked Echidna *Tachyglossus aculeatus* (Tachyglossidae: Monotremata), with observations on suckling of young after their emergence from the nursery burrow

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Abstract
The finding of the nursery burrow of a Short-beaked Echidna close to the house of the two senior authors allowed close observation and monitoring of breeding behaviour. Two young emerged from the nursery burrow eight days apart. Individual colour-marking of the mother and both young allowed their movements and behaviour to be monitored over subsequent months. Data are presented on post-emergence suckling of both young, which continued for 60 days after emergence, and included one instance when both were suckled simultaneously. Information is also presented on the movements, survival, and selection of shelter-sites by the juveniles. The two juveniles are likely to be twins, though they are not identical twins. These observations provide the first record of a female echidna successfully raising more than one young in a single breeding season, and the first records of parental care of young echidnas after they have vacated the nursery burrow. (*The Victorian Naturalist* **124** (6), 2007, 332-340)

Introduction

The Short-beaked Echidna *Tachyglossus aculeatus*, along with the Platypus *Ornithorynchus anatinus* and New Guinea Long-beaked Echidnas *Zaglossus* spp, comprise the egg-laying mammals (Subclass Prototheria, Order Monotremata). Echidnas differ from all other mammals by laying an egg directly into a pouch on their abdomen where it is incubated and the young hatches. (Platypuses have no pouch and lay their two eggs directly into a nest in the nursery burrow). The hatchling, which resembles a new-born marsupial in its state of development, develops in the pouch until it is capable of being left in a burrow while the mother forages. Young echidnas feed by sucking milk from one of two areolae located inside the pouch – there are no teats. Observations of the frequency of a mother's visits to the nursery burrow indicate that suckling occurs at intervals of several days (Griffiths 1978, Augee and Gooden 1993). However, the milk is rich in fats (Griffiths 1978) and a young can imbibe up to 40% of its body weight in a single feeding session lasting up to one hour (Rismiller 1999).

The Short-beaked Echidna is the most widespread of Australia's native mammals but, until recently, comparatively little was known of its biology and ecology (Griffiths 1978; Augee and Gooden 1993; Rismiller 1999; Augee *et al.* 2006). In south-eastern Australia, courtship and mating occurs from roughly mid-June to the end of July. Gestation takes 23 days, incubation of the egg in the pouch 9-11 days, and the young remains in the pouch for a further 45–55 days (Rismiller and McKelevy 2000). The young is then deposited in a nursery burrow, the entrance of which is plugged with soil after each visit. Here it remains for 115-170 days until emergence. Thus the period from conception to emergence is 6.5-8.5 months. Females rarely breed annually (Augee *et al.* 2006) and in a study on Kangaroo Island, South Australia, observation of tagged individuals indicated that females bred on average only once every 4-6 years (Rismiller and McKelevy 2000), a very low rate of reproduction.

There are very few records of more than a single egg being laid by the Short-beaked Echidna. Griffiths (1978, page 245) lists one instance of two eggs being found in a pouch and another of two pouch young. Augee and Gooden (1993, page 31) state that 'twins are known to occur rarely' without giving further details. Augee *et al.* (2006, page 82) state that 'usually only one egg is impregnated at a time, it is rare to

find a female carrying two young in her pouch.' Further, there appear to be no documented cases of female Short-beaked Echidnas raising to independence more than one young per breeding season. Here we describe observations of an individually recognisable female Short-beaked Echidna that was suckling two young that had emerged from the same nursery burrow eight days apart. We also provide the first documented observations of maternal suckling of young long after their emergence from the nursery burrow, and movement patterns and behaviour of the young until they increased their home ranges and could be found only intermittently.

Methods

Description of study area

The observations occurred in and around the garden of FP and JM at the Bend of Islands, a 400 ha area of high conservation-value bushland, located adjacent to the Yarra River, 33 km north-east of Melbourne. The area is zoned Special Use – Environmental Living under the Shire of Nillumbik Planning Scheme. This zoning prohibits the keeping of dogs, cats or other domestic or farm animals, restricts the planting of non-indigenous plants to a contained kitchen garden area near each house and prohibits the removal of native vegetation without a permit. The house is located on the Round the Bend Conservation Cooperative, a 128 ha property owned by 32 shareholders each with a 0.15 ha house site strategically located to minimise impact.

The vegetation is Box-Ironbark woodland with an understorey of native herbs, grasses and sparse shrubs. The dominant eucalypt species are Red Ironbark *Eucalyptus sideroxylon,* Long-leaf Box *E. goniocalyx* and Red Stringybark *E. macrorhyncha.* The house is surrounded by a verandah and by brick paving extending to a terraced-fill garden to the west and a terrace-cut garden to the east. A fenced transpiration bed/kitchen garden, garage, woodshed, garden shed and water tanks are located to the north of the house. There are no fences in the area and the nearest houses are 70 m to the north and 70 m to the east. The nursery burrow was 4 m north-west of the house at the end of a terraced garden bed.

The bush area adjacent to the house has the ground fuel reduced for fire protection. This is carried out sensitively on a five year cycle of patch raking or cool burning, so that in any year only 20% of the area is fuel reduced. Fallen timber, that is not fine fuel, is retained. All plants are indigenous except in the kitchen garden and some potted plants and ferns under the verandah.

Echidnas are not considered uncommon in the area. They are seen frequently in the summer when they come to drink and bathe in the garden ponds, particularly on very hot days.

Identification of individuals

The mother and four other adults that visited during the observation period were identified by detailed analysis of digital photos of the spines in their tails. The mother had a broken spine on the lower right side which facilitated her identification (Fig. 1), but the variation in shape, size and colouring of the individual tail spines made identification of each echidna quite feasible. The two juveniles were easy to identify due to differing size, spine density and colour of spines and fur (Fig. 2).

We initially marked the juveniles with paint on opposite sides of their tails. Later, small rings were made from the plastic insulation on electrical wire and three of these were glued to spines on the back, different sides and colours being selected for each individual (Fig. 2). The juveniles, the mother and one adult, of similar size and colour to the mother, were marked in this way.

Recording

To facilitate recording and communication each echidna was given a reference. The juveniles were B1 and B2, mother was M and other visiting adults were A1 to A4.

Initially, after the burrow had been noticed, photos were taken of the back-filled surface at the entry each time it changed, to record the occurrence of visits by the mother. When B1 was found being suckled outside the burrow, photo and video clip records were taken and movements were monitored fairly casually over the next week. When B2 was found being suckled outside the burrow, eight days after B1, photo and video clip records were also taken. The significance of multiple young was then established and movements and behaviour were monitored more closely by FP and JM.

Fig. 1. M suckling B1 at its emergence from the nursery burrow, 30 December 2005. Note M's diagnostic broken tail spine.

Monitoring generally involved periodically checking the location and activity of the juveniles. The frequency of observations depended on the activity levels of the echidnas, and our time availability. Typically we would go out about every hour or so and find B1 and B2 if possible, recording location and activity and always keeping an eye out for M or other adults. The difficulty of finding the juveniles increased as they developed and became more mobile, far-ranging, and adept at hiding. Recording comprehensive daily route information generally became impractical after the first four or five weeks.

Detection in the bush was much harder than in the immediate house surrounds. The best detection method developed for the bush was to remain motionless for at least five minutes and listen for movement of the ground litter. If no result, then move 20 m or so and start again. Temperature was recorded by a thermometer on the north wall of the house, under a 2.5 m wide verandah. Observations continued until the juveniles dispersed from the vicinity of the house in February. Intermittent observations were recorded until late March.

The following records[1] were kept:

- Record Summary Sheet – A tabulated record of visits by M or other adults and, when possible, the overnight shelter location, duration of activity period for the day, distance travelled for the day and the night shelter for each of B1 and B2, and notes on temperature, if 33° C or higher, and any notable activities.
- Daily Routes Plan – A separate A4 plan of the house and surrounds was used each day to record the location and time of each echidna whenever seen. The daily route was then plotted for B1, B2 and M or other adults, if sufficient data had been collected.
- Detailed Notes – A detailed account of significant events, if any, was kept in daily diary format.
- Digital photos and video clips were taken with a Canon Powershot S1-IS x10 optical zoom camera. The photo number, date and time were automatically recorded.

Minimal Interference

Our aim was to minimize interference to the echidnas, to enable observation of natural, unaffected behaviour. The echidnas were not handled except to attach the

marking rings. The juveniles were left to their own devices except that bowls of water were put out on days of extreme heat and an old door was used to provide shelter from sun or rain in two extreme circumstances.

Results

Chronological summary of observations

The nursery burrow was first found in early November 2005. Photographic records of changes to the earthen plug at the burrow entrance indicate a visitation frequency of 4-5 days. At least two visits to the burrow by the mother took place in the evening. Opening of the burrow entrance took up to one hour. While suckling was taking place a distinctive 'snuffley heavy breathing' could be heard from within the burrow. This sound was later heard at observed suckling events outside the burrow.

On 30 December 2005, B1 was found being suckled by M immediately outside the closed burrow entrance at around midday. B1 remained outside the burrow entrance all afternoon and was in the same location the following morning. Because of high temperatures (up to 42° C) an old wooden door was positioned above B1's usual resting site to provide shade on 31 December. As far as could be seen, B1 remained within 4 m of the burrow for the next week, making only short excursions in the adjacent garden and excavating three small shelter sites.

On 7 January 2006, B2 was found suckling from M next to the nursery burrow at 1300 hrs. B1 was about 4 m away in a small excavated shelter at the base of a sleeper wall. The main entry to the burrow had not been excavated (the surface was identical in photos taken on 5 January and later on 7 January). B2 had emerged from the nursery burrow via a small opening in the upper surface at the south end of the burrow (Fig. 3). This opening had not been noticed previously; however, a subsequent blowup of a photo taken on 5 January indicates that the opening may have been partially open at that time. There had been disturbance at the opening surface subsequent to 5 January, and when investigated on 7 January, it was found to provide narrow but clear access to the burrow. The opening could accommodate a juvenile the size of B2 but not an adult. M had been observed to walk over this opening at 1200 hrs when approaching the burrow. M left the area at 1430 hrs and B2 moved about until settling in an excavated shelter that B1 had previously made. B1 and B2 remained in their separate shelters over the following three days, gradually enlarging them.

On 11 January, following overnight rain, B1 was found in its shelter on its back in about 25 mm of water, cold and shivering.

Fig. 2. The two juveniles showing the variation in size, fur colour and the colour and density of spines. Left: B1 with red plastic markers. Right: B2 with green/yellow markers, 22 February 2006.

Fig. 3. The nursery burrow after excavation of the roof and loose material, 29 March 2006.

The shelter was drained, dry mulch provided and the old door was placed on the terrace level above to protect the shelter. That afternoon B1 moved about considerably, making three determined efforts to climb a 0.4 m high section of sleeper wall before finally succeeding and entering the shelter occupied by B2 (initially excavated by B1 between 2 and 5 January). They both stayed together in this shelter for the following three nights.

Each morning they ventured out together to bask in the morning sun (see front cover), then moved off independently, travelling further each day. B2 returned to the same shelter each night, whereas B1 used a different shelter site every night, including one night beneath tussocks (Silvertop Wallaby-grass *Joycea pallida* and Small Grass-tree *Xanthorrhoea minor* ssp *lutea*).

On the night of 18 January, B1 and B2 shared a new shelter site under the old door. At 1000 h on 19 January 2006, M was found at the shared shelter site suckling both juveniles simultaneously, 20 and 13 days respectively after B1 and B2 had emerged from the nursery burrow. M was standing tall on her front legs, with her forefeet turned outwards, her back arched, and her head between her front legs, possibly for added support. B1 was lying on its right side perpendicular to M's right side, with its head between M's front and rear right legs and well under M's body to access the areola. B2 was in a similar position on M's left side. Both B1 and B2 were making the rhythmic movements and sounds associated with suckling. This was the first sighting of M since B2 had emerged on 7 January.

B2 spent most of the following 10 nights in the garden shed, while B1 continued to use a different shelter site each night. On 23 January, M was observed systematically checking the shelter locations used by B1 and B2 on her previous visits. She then proceeded very deliberately to the garden shed, as if following a scent trail, and suckled B2 but not B1, although it was foraging within 3 m of the shed entrance. Subsequent observations of suckling are listed in Table 1.

From early February 2006, both juveniles moved increasing distances from the garden. Between 15 and 20 February, B1 was seen only once – 60 m from the house – and B2 was seen on only five of 13 days between 17 February and 2 March. B1 then returned and stayed in the vicinity of the garden between 21 and 28 February when it was suckled twice (Table 1). B2 spent long periods (24-48 hr) inactive in a shelter on 7 March, 12-13 March and 17-18 March, suggestive of having been suckled just prior to these times. The last sightings of the echidnas prior to the 2006 winter and the first sightings in spring are summarised in Table 2.

Subsequently, neighbours reported several independent sightings of B1 and B2 at a location 1200 m west of the house. Most visits near the house occurred on hot days and included a drink and swim in the ground level 'bird pond'.

Observations of suckling after emergence from the nursery burrow

Suckling after emergence was observed on 10 occasions (Table 1). Four of these involved B1 alone, 5 B2 alone, and B1 and

Table 1. Summary of observations of suckling by the two juvenile echidnas B1 and B2 after emergence from the nursery burrow. d = days.

Date	Time of day	Juvenile	Subsequent activity of juvenile
30 Dec 2005	1200	B1 on first emergence	Stayed outside nursery burrow for 3 d
7 Jan 2006	1300	B2 on first emergence	Stayed close to nursery burrow for 5 d
19 Jan 2006	1000	B1 and B2	Low level of activity for next few d
23 Jan 2006	1200	B2	Probably inactive for next 2 d
30 Jan 2006	1500	B1	Low activity level for next few d
7 Feb 2006	1842	B2	Low activity level for next 2-3 d
17 Feb 2006	1340	B2	Little activity for next 2 d
21 Feb 2006	1412	B1	Probably inactive for next 1.5 d
28 Feb 2006	1145	B1	Travelled 50 m then probably low activity for 2 d
3 March 2006	1336	B2	Travelled 100 m then probably low activity for 4 d

Table 2. Dates of last sightings before winter 2006 and first sightings the following spring for the marked echidnas.

Echidna	Last sighting before winter	First sighting after winter
M	31 March, 400 m w of house	19 August, first echidna seen near house
B1	19 March, near house	18 September, 60 m sw of house
B2	23 March, near house	19 September, near house
A4	21 March, last adult seen near house	

B2 were fed simultaneously on one occasion. On one visit M fed neither young, and once she was seen leaving the area, so it is not known whether she fed either juvenile. The sequence of observed feeding events, showing the interval (in days), and the juvenile concerned, was: **B1**-8-**B2**-12-**B1&B2**-4-**B2**-7-**B1**-8-**B2**-7-?-3-**B2**-4-**B1**-7-**B1**-3-**B2**. For B1, the intervals between observed suckling events were 20, 11, 22 and 7 days; for B2 12, 4, 15, 10 and 14 days (Table 1). The period from burrow emergence to the last observed suckling was 60 days for B1 and 55 days for B2.

Suckling Behaviour

M would sometimes spend a long time foraging in the bush around the house before, apparently, actively seeking out a juvenile to feed. For example, on 21 February M browsed for 2½ hours, including bathing twice, before feeding B1. However, once started, her search for the juvenile was focused – M would systematically check locations where B1 and B2 had been on previous visits and then proceed very purposefully as if she was following a scent trail.

On approach, the juvenile would usually freeze and M would prod it with her snout until it seemed to smell the milk and move to start to feed. Normally, the young suckled for about 20 minutes from one side before switching to the other side, presumably to access the other areola (Fig. 4). When feeding, the mother demonstrated a strong maternal instinct and tenderness towards the juvenile. After feeding was finished, M would typically rest for about 15 minutes and then move off and almost immediately commence foraging as she went. After feeding, the juvenile was sometimes active; on other occasions it would move to a shelter and rest for up to two days.

Visits by Other Adults

At least four adults (apart from M) visited the garden during the observation period. A4 was identified on 6 visits, A3 on 1, A2 on 1 and A1 on 2. There were also 4 adult visits where no photos were taken and identification was not possible. The only interaction observed between these adults and the juveniles was when B1 sniffed around one of the unidentified adults for about 15 minutes while the adult remained motionless. B1 then moved off.

Comparison of the juveniles

The juveniles were certainly not identical twins. B2 had blacker fur and more numerous, longer spines that were whitish with dark tips. B1 was smaller, had browner fur and less dense, shorter spines that were

buff with dark brown tips (Fig. 2). B1's colouring was similar to M's. When B1 left the burrow on 30 December 2005 it was significantly less developed than B2 was when it left the burrow on 7 January 2006.

Both juveniles grew significantly over the period from emergence to dispersal. At emergence B1 was approximately 40% of the length of M and B2 was slightly bigger. At dispersal B1 and B2 were both approximately 65% of the length of M. When first seen after winter, in September 2006, B1 and B2 appeared to be a similar size to when they were last seen in March, indicating that no significant growth occurred over the winter hibernation period.

Activities of the juveniles

The juveniles appeared to instinctively start digging and foraging from the day they left the burrow. They were capable climbers and actively curious. Their activities were highly unpredictable and apparently spontaneous. For example, B2 spent several days digging a shelter to a depth of 550 mm; it then left and did not re-use it.

They were often inactive until late in the morning, emerging from the overnight shelter at around 1130 h EST (daylight saving). The first activity was usually a sun-bath for 10 to 15 minutes (front cover). The period of active foraging, often interspersed with a sleep under some cover, varied from 0 to 8 hours per day. It was not unusual for them to remain in their overnight shelter all day. B2 remained in its shelter for more than 48 hours on at least two occasions.

The selection of overnight shelter seemed at times to be entirely random, yet at other times a location was used repeatedly over consecutive nights and sometimes re-used at another time. A wide variety of locations were used, ranging from a clump of grass in the bush to being hidden under equipment in the garden shed. On several occasions, existing holes in the ground, made by other animals, were used. At other times they excavated their own hole under a log or other cover. On 16 March, B2 was foraging when heavy rain began falling. It moved directly to a tree, 8 m

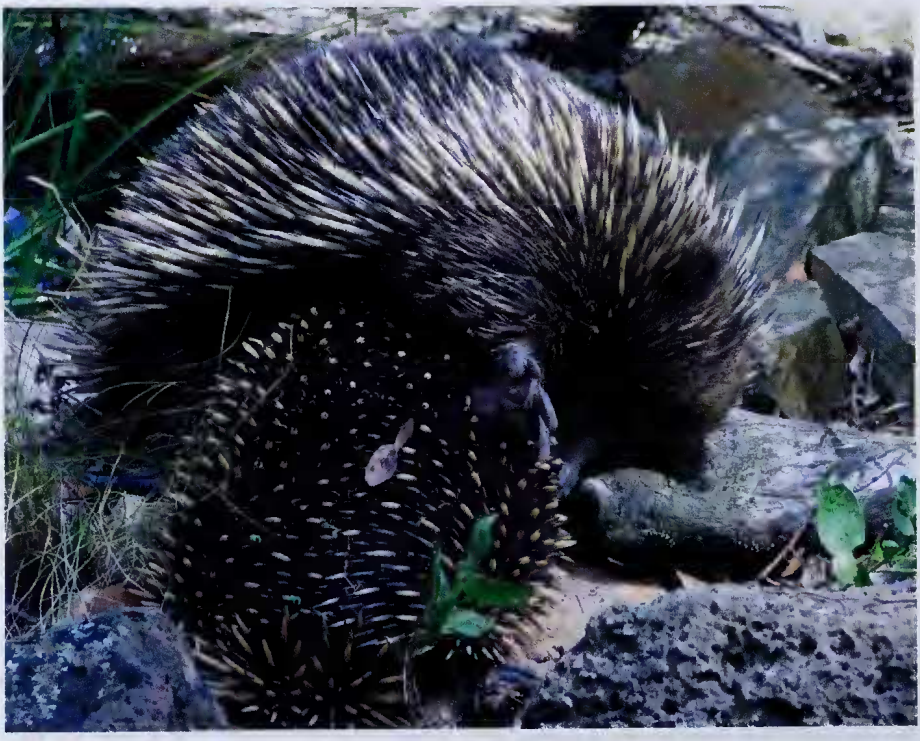

Fig. 4. M suckling B2 on 17 February 2006, 41 days after emergence from the nursery burrow.

away, which was hollow at ground level, and buried itself in the litter within the trunk where it was quite dry. It stayed there for the next 40 hours.

On one occasion, as B1 was walking along the top of a 1 m high sleeper retaining wall, it appeared to be using the crural spur near its hindfoot to stabilise itself while peering down the wall face.

Interaction of the juveniles

B1 and B2 were quite independent of each other. When they were together their relationship could be described as passive tolerance. There was little evidence of interactive play so typical of many baby mammals. This was surprising, given their active, inquisitive characters, but reinforces our knowledge of the solitary nature of the echidna. Similar passive tolerance has been observed between adults on occasions when they have simultaneously used the garden pond.

Nursery Burrow

The burrow was located behind a 460 mm high sleeper wall that retained the upper level of a 3-level terraced garden. M entered by digging under the sleeper wall from the 2nd level. The gravel surface above the burrow was level with the top of the sleepers and formed a hard crust. However, there were a number of small cave-ins where holes formed in the surface. On 18 December 2005 a juvenile echidna could be seen below a surface opening. A sheet of chipboard was placed over the opening. The covering had to be extended a number of times as new cave-ins occurred. By 28 December the covering had been upgraded to an area of 1 m by 1.5 m, with a steel plate covering another small cave-in through which a juvenile was seen on 23 December 2005. The upper exit was later formed at the 50 mm gap between this plate and the top of the sleeper wall. These observations indicate that the upper exit was constructed from inside the burrow.

The burrow was excavated and measured on 28 March 2006 after the juveniles had dispersed (Fig. 3). The burrow consisted of a main curved chamber, 1.5 m long by 300-800 mm wide. The effective clear height was 200 mm from the underside of the roof to the surface of the loose material on the floor. The depth of this loose material varied from 0 to 160 mm and was easily removed with a gloved hand to expose the base of the excavation. There were several side pockets with higher base levels that were perhaps used as rest chambers. The exit at the south end was accessed by a tunnel 120 mm wide by 90 mm high leading to a large shallow area where the surface had collapsed under the cover plates.

Given the activity levels of the juveniles immediately after their emergence, it is likely that they would have been actively digging in the burrow, perhaps explaining the surface cave-ins, loose material on the floor and the eventual construction of the upper exit used by B2.

No post-emergence use of the burrow was observed except that B2 spent a short time at the upper exit one very hot day when it appeared to be suffering from the heat. After the steel cover plate was slid to the east to enlarge the gap from the top of the adjacent sleeper, B2 only partially entered the exit, although there was clear access into the burrow where it would have been cool.

Discussion

Possibility of Adoption

Although we have no reason to believe otherwise, we were unable to prove that the two juveniles were siblings – DNA primers were not available to allow identification of parents in the Short-beaked Echidna (D. Middleton, Healesville Sanctuary, and P. Rismiller pers comm.). Therefore we cannot discount the possibility that one of the babies was adopted by the mother, perhaps after having been dislodged from the pouch of another female, or being found in a nearby nursery burrow. Cases of adoption of pouch young are known to occur in marsupials, including macropods and bandicoots (Gemmel 1988) but would seem unlikely in a solitary animal such as the Short-beaked Echidna. Regardless, our observations represent the first record of a female Short-beaked Echidna raising more than one young per breeding season.

Patterns in suckling within the burrow

The frequency of M's visits to the burrow (every four to five days), as estimated from observed changes in the soil plug at the burrow entrance, are consistent with published data on suckling rates of between 3 and 6 days (Griffiths 1989; Rismiller and McKelvey 2000), despite the fact that she was presumably suckling two rather than

one young. Whether this delayed development of the young is not clear but it does not seem to have had a major effect as their stages of development at emergence fall within the documented range and both survived their first year outside the burrow, suggesting that their nourishment was adequate.

Patterns in suckling after burrow exit

These observations represent the first documentation of continuing maternal care in the Short-beaked Echidna after the young has left the nursery burrow. All other authors state that the young is abandoned by the mother once it has been suckled immediately after first emergence (Griffiths 1989, Augee and Gooden 1993, Rismiller 1999, Augee *et al.* 2006). However, our observations indicate that suckling can continue for up to 60 days after the young leaves the nursery burrow.

There was no obvious pattern in the length of intervals between the observed feeding events, which ranged from 4 to 22 days, but they were considerably longer than the four to five day intervals recorded during the nursery burrow stage. It is almost certain that other feeding events occurred unobserved – M could move quickly and was amazingly cryptic. It would be reasonable to assume a detection rate in the order of 50%.

Inclement weather

As echidnas have a normal body temperature of 33° C and do not sweat or pant, they are vulnerable to heat stress (Augee *et al.* 2006). The juveniles seemed to cope well on hot days. B1 was initially suckled outside the burrow in 39° C heat. For the rest of that day and the following day, when ambient temperature reached 42° C, B1 remained outside the burrow almost completely buried in the surface soil. A door was placed to provide shade for B1.

B2 seemed to be heat stressed on 26 January 2006. It was 39° C late in the afternoon when B2 partially entered the upper exit of the nursery burrow. Fortunately a cool change arrived. We placed water bowls near B1 and B2 on very hot days. They drank some water but B1 wanted to climb into the bowl and B2 typically tipped its bowl over. On at least one occasion both B1 and B2 were found cold and wet after selecting inadequate shelter sites during rainy weather. However, as they developed, they seemed to learn to find dry shelters during rain, as observed on 16 March.

Activity periods

B1 and B2 were active for much of the day, except for early morning. They seemed to wait until the sun was high and then often sunned themselves, sometimes on a paved surface before beginning to forage. Although nocturnal monitoring was limited to searching on only a few nights, we formed the impression that B1 and B2 were mostly stationary at night. B1 was found in a different shelter in the morning on two occasions and we do not know the timing of these movements – they could have occurred at or just after dusk, after we had assumed it had settled for the night, or at any other time before our first morning check.

The opportunity to monitor the echidnas so close to the house is testament to the success of the local planning provisions that prohibit domestic pets and aim to maintain and advance the environmental integrity of the area.

Acknowledgements

We thank Peggy Rismiller for her advice and encouragement during the observation period.

Note

[1] Detailed records of our observations, including photos and videos of most suckling events, and a geometric Plan and Section of the nursery burrow can be made available upon request.

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